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ABSTRACT

The reasons for schools' lack of leadership in using microcomputers for technological diffusion are explored in this article. General systems theory is used to examine the effects of the computer revolution on political, social, economic, and educational systems. Selected characteristics of schools and computers are offered as possible explanations for education's reactions to the computer revolution. Two future scenarios are discussed: resistance to change, which results in increased irrelevance of educational institutions to the external environment and their eventual decline; or adaptation, which is accomplished by rational planning for computer system selection and implementation. An extended bibliography is included. (LMI)

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THE EFFECT OF THE COMPUTER REVOLUTION ON EDUCATIONAL DELIVERY SYSTEMS

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Abstract

Microcomputers allow teachers to provide more efficient and effective instructional delivery systems; however, schools have not been leaders in technological diffusion as have other organizations. This article explores some possible explanations for this. General systems theory is used to examine the effects of the Computer Revolution on political, social, and economic arenas and the resulting new inputs to educational systems. Selected characteristics of schools and computers are offered as possible explanations for education's past reactions to the forces of the Computer Revolution. Two future scenarios for schools are then discussed: resistance to change, resulting in increased irrelevance of educational institutions to the outside world and their eventual decline; or adaptation to the changing environment, accomplished by rational plans for computer system selection and implementation.

THE EFFECT OF THE COMPUTER REVOLUTION ON EDUCATIONAL DELIVERY SYSTEMS

The Computer Revolution has produced new and powerful tools which have the potential to radically alter instructional delivery subsystems within schools. Microcomputers have created opportunities for educators to achieve new goals or to accomplish old tasks in better ways. However, while educational organizations are being urged to keep ahead of or at least current with technological trends (Raub, 1982), schools often design and use computer systems poorly (Larer & Moursund, no date; Winerip, 1983).

To help understand the actual and potential effects of microcomputers upon present school operations, general system theory concepts, drawn largely from the interpretation of Immegart and Pilecki (1973), will be used to examine the relationship between the Computer Revolution and education.

The School as an Open System

No system lives in isolation. An interdependence exists among the activities and characteristics of the system itself, its internal subsystems, and its outside world, the environment. All systems are affected by and may be contained in larger environmental systems, or suprasystems. The open system reciprocates with its environment in a free exchange of energy, materials, and information. System actions influence suprasystems in the

environment, and outside forces affect internal system structures and functions: a change in the environment can precipitate a change in the system and vice versa. New and different inputs from the environment are the result of competition from, changes in, or evaluation by various suprasystems. So to remain healthy, it is important for a system to remain aware of as large a sphere of environmental activities and attributes as possible (Hall & Fagen, 1956; Hanson, 1979, p. 191; Immegart & Pilecki, 1973, chpt. 2, p. 89).

The school is an open system because it exists in an exchange relationship with its environment. The school receives inputs from and contributes outputs to its economic, social, and political suprasystems. Because of this reciprocity, educational institutions are expected not only to maintain themselves, but also to support and serve society. They are most often evaluated on how well they perform this latter function (Hanson, 1979, pp. 362-363; Immegart & Pilecki, 1973, pp. 31, 36-37, 39).

At any point in time, the state of the environment can be found on a continuum between placid and turbulent (Emery & Trist, 1965, pp. 21-32). We are presently in an era of "earthquake change" (Hanson, 1979, p. 321) due to the forces of the Computer Revolution. New electronic technologies are rapidly changing economic, social, and political arenas (Levin, 1980; Schuurman, 1980, p. 19). Because the school is an open system, changes in these suprasystems will have

implications for education.

The Computer Revolution and the Economic Suprasystem

Computers are revolutionizing the world of work (Gendron, 1977, p. 30) and are causing both inadequate demand unemployment and structural unemployment (Bloom & Northrup, 1981, pp. 491-494). Schools are under pressure to combat these problems by preparing young people for jobs that will truly exist when they graduate and by developing curricula in line with modern innovations (Hugh-Jones, 1969, pp. 9-10; Schmandt, 1970a).

Currently, there is public demand for educational reform. Technology may provide a solution to the problem, for it allows schools to economically meet diverse and growing needs (Oettinger, 1969; Willett, Swanson, & Nelson, 1979, p. 89). However, innovations can be used to improve cost-effectiveness in schools only if physical capital is substituted for, rather than added to, labor. This may result in the reduction of the largest portion of the school budget, staff salaries (Vaizey, 1972; Willett et al., 1979). Present curricula can be taught in one-third the time using computer-assisted instruction (Dede, 1981, pp. 307-308), and more courses can be offered without increasing the number of faculty (Caldwell, 1981, p. 267; Suppes, 1975, pp. 175-178).

New tools may transform the role of the teacher into that of a specialized professional, knowledgeable in content areas as well as in instructional techniques (Willett et al., 1979, pp. 48, 190-191). Machines can dispense

information, thereby freeing professional educators to spend more time with individual learners. Teachers can help students grow in both cognitive and affective skill areas by diagnosing, prescribing, facilitating, interacting, motivating, and evaluating (Carter, 1962, pp. 11-12; Schmandt, 1970a; Willett et al., 1979, pp. 74, 77-78, 87, 190-191). Unfortunately, teachers prepared to effectively use computers for either delivery or management of instruction are in short supply (Walker, 1983). Thus, there may be a need for more in-service training programs for educators (Lipson, 1981, pp. 32-33).

The Computer Revolution and the Social Suprasystem

Primary technical effects of an innovation are soon felt; secondary ramifications take many years to develop, but are more long-lasting (Dede, 1981, p. 306). By altering beliefs, customs, and practices, a technological change often becomes one aspect of an accompanying social change (Willett et al., 1979, pp. 181, 272).

Computers are increasing the rate of societal change, a phenomenon many people find unsettling (Schuurman, 1980, p. 19). This may place demands on schools to help children and adults adapt by developing intellectual and social skills to deal with the inevitable (Brown, 1981, p. ix). To accomplish this, teachers should feel comfortable with both the new technologies and change processes. Methodologies should be found for teaching these coping skills, and curricula should be updated (Caldwell, 1981, p. 267;

Mesthene, 1965; Schmandt, 1970a). Furthermore, school administrators must focus more on anticipation of and adaptation to change. They must cope with production changes and new techniques for data manipulation and decision-making, as well as employees' reactions to technology (Brodrick, 1969, pp. 48-50, 61).

Public desire for alternative educational delivery systems may hasten the diffusion of computers in schools. Individualization of instruction via new technologies may mean the end of discontinuous learning and artificial conventions (Willett et al., 1979, p. 53). Currently, a child's progress in school is measured and expressed in terms of time spent, rather than learning achieved (Morrison, 1940, p. 666). In a capital-intensive institution, the amount of time a student spends in school may become a means for achieving certain goals. In fact, learning time may increase, while hours physically spent in school may decrease. This may benefit students because they could avail themselves of increased opportunities to explore career options through part-time employment (Willett et al., 1979, pp. 86, 187-189). Electronic networking of schools, businesses, libraries, and government organizations may allow educational delivery systems to become more decentralized and informal. As instruction becomes available in non-traditional settings like the home, people will have greater access to learning experiences, which may increase the demand for schooling (Dede, 1981, pp. 307-308).

Traditional methods of expanding educational services may prove too costly, creating an additional incentive to incorporate new technologies in places of learning (Hansen, 1965, pp. 64-75; Montgomery, 1974, p. 172).

The Computer Revolution and the Political Suprasystem

The distribution of electronic technologies is an educational cost-benefit dilemma. Market forces will not guarantee equity: computers are expensive, and schools that service clientele who may most benefit from exposure to current technologies may not have available funds. A study by Market Data Retrieval, Inc. (cited in Tursman, 1983) found that there are more computers in wealthier school districts, with less affluent districts making some gains in computer implementation. Rowan (1983) reported that in Fall 1982, 72.6% of the nation's richest districts had instructional computers, compared to only 45.5% of the poorer districts. He also felt that poorer schools having a history of ill-equipped science laboratories and mediocre libraries will probably not provide their students with the computer skills needed to be competitive in the job market. Thus, those who attend schools with few computers may be at a life-long disadvantage. Also, software manufacturers may produce programs geared to the needs of those who can afford to pay, rather than for diverse populations (Dede, 1981, pp. 309-311).

Market distribution of new technologies is often determined by social and political forces, not economic ones (Hugh-Jones, 1969, pp. 11-13); therefore, the public can influence educational policies on technology through political action (Allison, 1969). Indeed, the very term politics can be used to describe the decision-making process that determines the allocation of power or material goods in society (Mesthene, 1970, p. 63). Those concerned about inequitable diffusion of computers can put pressure on the government to use its political and financial powers to promote research and development activities and subsequent assimilation of new technologies into the economy, as does the Japanese government (Freeman, Clark, & Soete, 1982, pp. 197-199). For example, Lipson (1981, pp. 32-33) suggested that before technology improves education, there must be more support units at the state or local level and changes in purchasing regulations and school budget formation. In the future, greater use of networking may spur new government policies that allow increased cooperation between schools and public utilities (Dede, 1981, pp. 307-308).

Present Reactions of Schools To New Inputs from the Environment

Despite the benefits of the new tools, the forces of the Computer Revolution are causing a state of stress in educational systems. New inputs resulting from technologically-induced changes in economic, political, and social suprasystems are causing entropy in education by

disrupting the operational status quo. It appears that education is compounding this problem by displaying a lag in response to these stimuli. Schools are not nor have been leaders in technological implementation (Johnson, 1978, p. 9), using computers less than other institutions (Brown, 1981; Licklider, 1979).

What causes a lag in system response to a state of stress? It can be the result of a denial of threats and a resistance to change. Systems of all kinds tend to resist change. The status quo becomes comfortable, and only gradual modifications are tolerated. In addition, change is opposed when livelihoods or social standings are threatened. Systems of all kinds also resist a loss of integrity; they try to obstruct any force which threatens their self-esteem and their ability to function competently and autonomously (Klein, 1976, pp. 117-120).

School systems may be lagging in technological diffusion because of resistance to change--change that is often frightening in its magnitude, rapidity, and irreversibility (Klein, 1976, p. 119). Moreover, school systems may perceive both macro and micro threats from the new computer technologies. The livelihood, social standing, and integrity of both the school and its staff members may be affected by the Computer Revolution. Certain characteristics of schools and of the new tools themselves may be contributing to this anti-technological bias. These are examined in more detail below.

The Present Organization of Schools

Diffusion of new tools in schools is often hampered by economic, technical, and organizational barriers ("Harvard University," 1972; Lidtke, 1981; Montgomery, 1974; Oettinger, 1969; Willett et al., 1979). Sectors of the economy which are older or not technologically-oriented tend to have longer diffusion rates. This may account for the slowness of legislative, organizational, and social changes in service industries, such as education (Freeman et al., 1982, pp. 122, 124).

School district organization may also impede technological advancement. Schools lack centralized leadership because each district is locally governed. However, the freedom that decentralization offers is not often maximized by educational organizations (Coombs, 1968, pp. 6-7; Oettinger, 1969).

Tradition

Tradition plays an important role in schools in setting organizational norms; however, tradition can also be used to perpetuate the status quo and resist change (Leonard, 1986, p. 7; Morgan, 1981, p. 90). Because computer-assisted instruction (CAI) and computer-managed instruction (CMI) differ vastly from traditional delivery systems, teachers and administrators are often reluctant to embrace the new technologies (Hershfield, 1981, pp. 3, 9).

Perceived Effects of Computer Technologies

Educators fear replacement by computers and the resulting unemployment (Hershfield, 1981, pp. 3, 9). It may be possible to use CAI to increase class size and reduce the teaching force without a corresponding decline in student achievement (Averch, Carroll, Donaldson, Kiesling, & Pincus, 1971, p. 155; Caldwell, 1981, p. 267; Suppes, 1975, pp. 175-178; Willett et al., 1979). In fact, in a modern man-machine educational delivery system, the pupil-teacher ratio takes on new meaning: increasing the ratio can increase the productivity of teachers, yet individualized instruction can still take place (Willett et al., 1979, p. 74).

Some predict that CAI, CMI, and information networks will eliminate traditional schools altogether. This may be hailed as enlightened education by those who see schools as a means to academic achievement (Naur, 1975, p. 946), but there may be a number of threatening side-effects to teachers, parents, and students: unemployment among the ranks of educational personnel, elimination of the custodial function of schools (Willett et al., 1979), and a decrease in the number of extra-curricular activities available to students (Naur, 1975, p. 946).

Resistance may be generated by the outputs of computers in the classroom. Electronic teaching devices may help individuals learn more efficiently and more effectively, but they can also give students distorted views. Computer-assisted simulations may stress the model itself, rather

than the application of it to the real world. Furthermore, the underlying principles of modeling and simulation may be lost in the complexities of the computer program (Naur, 1975, pp. 945, 947).

School personnel are concerned that computers will depersonalize the teaching-learning process and will cause technologically-induced job alienation (Hershfield, 1981, pp. 3, 9). Teachers are aware of the job alienation experienced by industrial workers where assembly lines, piece work, and robotics remove the individual from the final product (Schuurman, 1980, pp. 34-37, 213, 366).

Problems with Computer Software

Problems with commercially prepared software may also contribute to resistance to computers. Creating good programs for today's microcomputers is labor-intensive and therefore expensive. Lack of standardization among different brands of computers may be contributing to the cost of programs. Software houses that wish to serve a large market write programs compatible with many types of machines; the increased production costs are then passed to consumers (Caldwell, 1981, p. 264). To reduce the price of software, programs could be centrally produced for a large market of instructional computers, but this could hinder local curriculum control (Dede, 1981, p. 307); however, development of educational software has not had the highest priority (Brown, 1981, p. x). When such programs will be produced on a large scale, they may be based upon a

philosophy of convenience, rather than upon established learning theories (Nievergelt, 1975, p. 468).

Future Reactions of Today's Schools To the Computer Revolution

Schools can react in two ways to the system entropy caused by the Computer Revolution. They can fail to maximize the use of microcomputer technology, causing schools to weaken and decay, or they can adapt to the changing environment and grow.

Decline and Breakdown

A system can hasten its own death in many ways. It can harm itself by becoming more closed than open. Although no system is either entirely open or completely closed, closing systems tend to reduce the flow of energy, materials, and information between themselves and their environments. Such systems become isolates and subsequently choose to ignore external forces, especially if they are of a threatening or critical nature. If negative inputs are blocked, the system may become dysfunctional. Entropy may increase, until the closed system is finally replaced by a new, open system that is more vital and relevant.

Furthermore, if a system acknowledges a threat, but fails to expend adequate and appropriate energy and resources to combat the resulting chaos, system disorder will increase. System stress will also be promoted and decline encouraged if inputs are drained and eventually

exhausted in the process of negentropy. This can result from either a protracted battle against system threats or an overreaction syndrome.

Lack of negentropic actions may lead to educational systems more closed in nature and their eventual demise. If schools fail to acknowledge and act upon the effects of the Computer Revolution, they quickly may become dysfunctional, irrelevant, and replaceable. The problem can be further aggravated by negentropic actions that are random, purposeless, or unplanned. Schools that use their limited resources in a haphazard process of computer system design may be left with drained coffers, unsatisfactory computer systems, and increasing distances between education and the outside world.

Adaptation and Growth

System stress can become a positive force if it causes electronic tools to be used constructively in schools, resulting in educational organizations that can better serve a changing technological environment. Several authors (Mesthene, 1970, p. vii; Schmandt, 1970b) warned that if our social and political institutions are to survive and if technology is to be used wisely, systems must change. New tools should be used to solve problems, not to create them (Friedman, 1981, p. 295). Resistance to entropic forces does not contribute to system adaptation and growth; further entropy ensues because energy and resources are consumed in the process of combating disorder. Only by changing to

accommodate new inputs and thereby improving its processes and outputs can a system both contribute to its environment and be enhanced by it. System stress will become a positive force if it causes electronic tools to be optimally used in schools, resulting in educational institutions that can better serve a changing world.

Systems need four conditions to change and grow: inputs from the environment; the presence of entropy; characteristics of the open system, including the capacity for adaptation; and purposeful system action. The first three conditions have already been met. However, schools themselves must themselves provide the last condition for change: planned, prescriptive response.

Planning is the vehicle which can promote rationale action in the face of irrational inputs (Griffiths, 1969; Hanson, 1979). Comprehensive plans are needed when designing computer systems because a new or improved system can affect all parts of an organization (Watson & Carroll, 1980). Plans supported by the research will help school decision-makers avoid trial-and-error mistakes that cost time and money. A more efficient and effective design process can then lead to better use of the resources allocated to computer system development.

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